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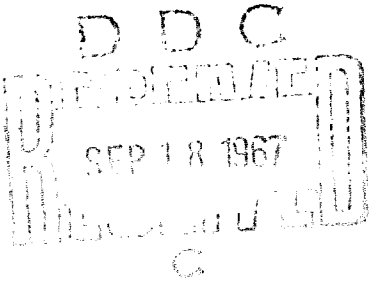
A PERSONNEL COST DATA BANK FOR USE IN STUDIES OF COST AND EFFECTIVENESS

Marilee N. Connelly



A PERSONNEL COST DATA BANK FOR USE IN STUDIES OF COST AND EFFECTIVENESS

by

Marilee N. Connelly

August 1967

Task PF 0160201H01

Research Memorandum SRM 68-3

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SUMMARY

The purpose of this study is to develop the structure of a data bank system which will facilitate the acquisition and computation of personnel costs needed for cost/effectiveness predictions. The Navy's need for adequate personnel cost information, especially during the development of new systems, was investigated. Data bank systems and cost models were examined. None, however, could provide predictive, system oriented personnel costs upon which to base function allocation decisions. The concept of using a computerized system for cost acquisition and computation was evaluated and found feasible. Consequently, the structure, contents, and formulae to be used in such a data bank system were derived and are formally proposed within this report. The tasks required to develop the system are delineated.

On the basis of this research, it is recommended that the personnel cost data bank system proposed herein be fully developed as soon as possible. Solutions to the problems of establishing, maintaining, and using the system for system development cycle support should be sought during the time the cost data system is being developed. The system should be implemented, maintained, and used as soon as possible.

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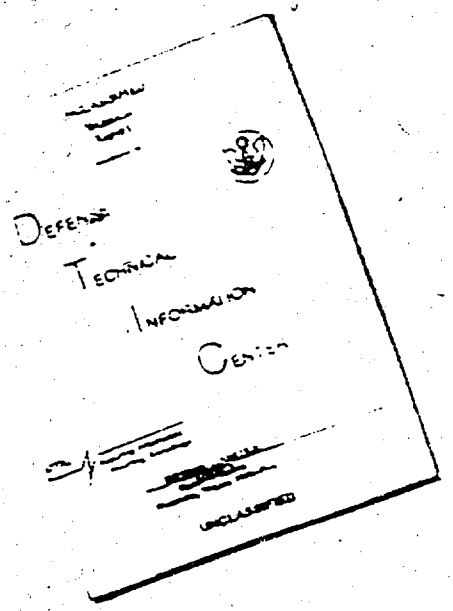

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CONTENTS

CONTENTS (cont'd)

Page

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

A. Purpose

This study is part of a continuing effort to develop a useable cost/effectiveness methodology for man/machine function allocation. The specific purpose is to develop the structure of a data bank system which will facilitate the acquisition and computation of the personnel costs used in cost/effectiveness predictions. The research being reported was conducted under Task Objective PF 016020801, Cost/System Effectiveness.

B. Scope of Report

This report presents evidence of the feasibility of establishing, maintaining, and using a systematic method of acquiring and computing predictive personnel costs. The conceptual phase in the development of a computerized personnel cost data bank and computational system is presented. Included are the types of formulae, data, and programs required; the probable users and uses; the tasks associated with establishing, maintaining, and using the system; and some of the administrative and cost considerations associated with the proposed system.

C. Background

Three previous end products have been published in conjunction with this project: a bibliography of cost, effectiveness, and man/machine function allocation studies (48), a study of the feasibility of deriving a cost/effectiveness formula for man/machine function allocation (15), and a progress report defining the problems of obtaining quantitative indexes of personnel performance effectiveness (50).

During the cost/effectiveness research, it has become apparent that the present methods of acquisition and computation of Navy personnel costs are inadequate to provide suitable predictive, system-oriented personnel costs to meet present Navy needs.

D. Source of the Data

The information in this report is based on interviews with cognizant personnel in the Bureau of Naval Personnel and at the U. S. Naval Personnel Research Activity, San Diego, data processing literature, and previous personnel costing research.

II. THE PROBLEM

A. The Need for Personnel Costs

Personnel costs are needed for many of the cost/effectiveness analyses conducted in the Department of Defense and in the Navy. In order to be of value these costs must be valid, reliable, comparable, and accurately computed. Valid costs include all/only pertinent elements, reflect the real situation, and are appropriate to the situation. Reliable costs consistently include the same previously identified elements. Comparable costs allow the comparison of alternatives and include items of similar function in the total cost of each alternative. Accurately computed costs include those computed and modified by the correct evaluation of a mathematical formula.

Cost/effectiveness analyses of Navy military operations require personnel costs to use in determining the cost of implementing a new system, to decide which of several systems is to be purchased for Navy use, and to provide a basis for research and development of new weapon systems. Eventually, engineers and personnel researchers may use personnel costs to make man/machine function allocation decisions on the basis of cost/effectiveness. Personnel researchers developing manning and training requirements for systems not yet in the fleet need personnel costs for use in cost/effectiveness tradeoffs between alternative manning options and training recommendations.

In future years the number of requests for Naval personnel costs will increase as resource constraints become more apparent. Most of these requests will originate with system developers who are already aware of the value of cost/effectiveness analysis and of the high costs resulting from man's presence in a system or aboard a ship.

In most cases the time period during which the needed cost data remains valid is limited. This is particularly true when such data are to be used as a partial basis for operational or system design decisions. Therefore, any system designed to meet personnel cost needs must be readily available and must supply data quickly upon request.

B. The Present Methods of Personnel Cost Acquisition and Computation

At the present time personnel cost systems are of limited usability in that they do not allow the users of personnel costs to acquire current cost values conveniently. However, selected personnel costs have been computed and published by Clary (10, 11, 12, 13, 14), and Arzigian (2, 3, 4, 5). These data were originally intended for use in computing personnel replacement costs. Once published, however, such data quickly lose their validity and are therefore not applicable to many situations in which predictive personnel costs are needed.

In order to obtain a personnel cost value the investigator must learn which elements are needed for the computation, where to find the values of these elements, and how to combine the elements into a meaningful personnel cost. Several reports are available which supply methods and concepts of personnel cost computation (2). Others furnish limited formulae and sources of cost elements (15).

Cost data are generally not available through usual formal channels. In many cases, personal contact, and usually a "need to know", is required to obtain cost data.

Combining cost data into meaningful form occasionally introduces arithmetic and mathematical errors. Erroneous assumptions are also possible since even experienced cost analysts may be unfamiliar with some of the many personnel factors and costs.

Cost source organizations also encounter difficulties with the present cost acquisition methods. Unbudgeted time and money are expended updating and recording costs and servicing the overlapping requirements. Frequently, an absolutely factual presentation of costs will seem honestly detrimental to the mission of the reporting organization through potential misuse or misinterpretation of cost data. Sources understandably suspect that some individuals may inadvertently use the data so as to present an erroneous image of the true situation. It is small wonder that costs are quoted reluctantly or that all of the pertinent elements are not necessarily included (25, 26).

The conduct of personnel cost research may be grouped temporarily into two overlapping phases; acquisition and computation. Acquisition includes obtaining a list of the necessary elements and their sources, contacting the appropriate supplying organizations, and obtaining the correct and current data. Computation involves the total computational process identifying the needed elements, obtaining or deriving a formula for the specific intended use, learning applicable costing methods, selecting and using the correct value in the formula, and computing the cost in an arithmetically correct manner.

III. THE PROPOSAL

A. General Concept

The feasibility of developing a single automated system to solve the problems of personnel cost acquisition and computation should be considered whenever (1) the number of alternatives becomes too large to be handled manually, (2) the formulae are too complex to handle easily, (3) the data are too difficult to acquire for each computation, or (4) computing assistance is required for speed and accuracy. Some of the advantages offered by an automated data bank and computation system over an equivalent manual computational system are (1) greater speed in costing alternatives, (2) better computational accuracy, (3) better capability for testing major assumptions, and (4) better documentation of results. Since all the above conditions are extant, available types of data banks and computational systems were examined.

There are many kinds of data banks. Strictly speaking, a data bank is an organized collection of information on one subject. A bibliography is a coarse data bank containing references related by topic. An indexed list of raw data is another type of data bank. Modern libraries are now using computerized storage and retrieval which allow the recall of titles, subjects, and authors' names for a large number of documents. Cost data and models have been stored in similar computerized storage and retrieval systems.

Computational systems also vary in complexity. Mental arithmetic, pencil and paper calculation, adding machines, desk calculators, and computers of various sizes and degrees of complexity are all included in the term "computational systems". The computer is the most complex and, compared with manual calculation, it offers the distinct advantages of greater speed in evaluating a formula, better computational accuracy, and better documentation of results.

Cost data banks and computational systems have already been combined successfully. One example of a computerized cost data bank is the ISOC model constructed in 1965 by the Research Analysis Corporation (1). This model provides computer framework within which any number of different individual system or organization cost models may be applied. Another similar data bank is Mitre Corporation's Computerized Electronic System Cost Model (34). These systems are combination computerized data banks and computational systems in that they store and retrieve cost elements and compute costs according to specific models and formulae.

The considerations listed in Table 1 compare a proposed computerized data bank and manual computational methods of cost acquisition and computation. It was the disclosure of the advantages shown in Table 1 which led to the present proposal of a computerized system for personnel cost storage, retrieval and computation.

B. The PRL Cost Model as It Relates to Early R&D Needs

Gettings (23, 24) has proposed an "enlisted cost model" for cost acquisition and computation which uses computerized data banks and models. His proposal contempletes a central computing system and auxiliary data banks and uses the same formula formerly used by Clary (10, 11, 12, 13, 14) and Arzigian (2, 3, 4, 5).

The primary purpose of the model is to calculate the accrued cost of individual enlisted personnel currently serving in the Navy. It could generate individual historical personnel costs suitable for personnel cost accounting. This system could alsc calculate current training costs and the costs of replacing a man in an existing rating. The computation will, however, include only recognized personnel cost elements which will be based exclusively on the present and past personnel systems and personnel costs.

Personnel costs which are to be used predictively and in conjunction with emergent systems, on the other hand, must be computed with regard for certain additional criteria and assumptions. The cost of personnel in a system must be based on the function performed in the system rather than on the cost of replacing a man in a particular rating. Costs used in system development cost/effectiveness tradeoffs must be predictively oriented since neither manning, training, nor equipment will be rigidly defined at the early time in system development when these costs will be needed. The costs will refer to hypothetical cases of combinations of skills and experience required to perform a given function in the proposed system. The use of costs based on the historical records of a similar case might introduce the erroneous assumption that the Navy rate/rating structure, manning, and training policies will not change as new equipment and technology are introduced. Cost elements must be carefully selected, enabling the analyst to compare and contrast the different possible personnel and equipment costs. Comparative cost elements must include the same types of items for both men and equipment. Contrast is then discernable when all of the elements which are uniquely included in the cost of using a man in a system are traded off against all of the costs of substituting a machine for the man.

TABLE 1

Acquiring and Computing Personnel Costs: Present System Versus Proposed System

General Considerations

ITEM	PROPOSED SYSTEM (AUTOMATED DATA BANK AND COMPUTATIONAL SYSTEM)	PRESENT SYSTEM (MANUAL DATA COLLECTION AND COMPUTATION)
1. Accuracy of results	Very accurate, eliminates most human errors.	Not consistently accurate. Human errors occur.
2. Documentation of results	Documentation is easily printed out upon request.	This information must be compiled through the time and effort of personnel.
3. Data acquisition	Personnel activities must be directed to furnish data to the computing center.	Where data is not furnished by personnel activities, personnel researchers must arrange for obtaining it.
4. Currentness of results	Obsolete data will not be used unless current data is absolutely unavailable.	Obsolete data may be used for convenience or of necessity.
5. Time to compute costs	Very rapid computation. Simple and complex formulae handled with ease.	Slow tedious computation. Complex formulae are often difficult to compute or are not computed correctly.
6. Handling complex formulae	Time only slightly increased over that required for simple formulae.	As compared with the computation of simple formulae, accuracy is reduced and time is increased.
7. Handling several alternatives	Several alternatives are handled with ease.	Additional alternatives add to the burden of data acquisition and computation.
8. Testing assumptions	Costing assumptions are easily tested; cost sensitivity analyses are quickly performed.	Assumptions may be tested only through numerous computations. Cost sensitivity analyses are too complex to be feasibly performed through manual computation.

The model proposed by Gettings does not appear to include the features required to adapt it to cost/effectiveness trade-offs such as those needed during early development of systems. It is, rather, limited to historically based, rating-oriented costs of replacing a man in a given rating. The data bank system proposed in the present report represents an attempt to meet the still unfulfilled needs for personnel cost information for application beginning early in the system development cycle.

C. Detailed Concept of a System Oriented Personnel Cost Data Bank

The proposed basic system model is based on a formula developed for determining the cost of personnel in function allocation alternatives (15). The formula is presented for reference in Appendix B. Although this formula will make the data bank suitable for use in early system development, variations may be written which will allow other personnel costs to be generated, such as those used in manning and training trade-offs. Standard rate/rating replacement costs may also be computed.

The formula is the mathematical combination of many simple specific elements. The branching diagram in Figure 1 shows this structure. In the proposed data bank system the data will be stored in elemental fashion in order to provide maximum possible versatility of use. This structure will allow new elements to be added to a formula at any time, new improved methods of computation to be easily implemented, and new formulae and programs to be used without reworking the data. Further, such format will facilitate better documentation of costs, better analysis of errors, and increased ease of "cost sensitivity analysis", a method of checking costing assumptions.

The internal structure of the data bank will consist of a matrix of approximately 200 elements by 200 values in size. These 200 elements may be divided into four classes; "input data", "stored data", "computed and stored data", and "reported data". "Input data" is composed of those elements which will be supplied by the user with each problem he presents. They will be specific to the problem and must be supplied for each problem and alternative being costed. Table 2 lists some of these required inputs. "Stored data" consists of elements which will be provided for the data bank by cost source organizations. They are the specific simple elements mentioned above, which will be stored on magnetic tape for later computation into cost factors and ultimately into personnel costs. "Computed and stored data" elements will be cost factors such as "the training cost of an ET3". They will not be total man costs but will be major factors computed and stored for direct retrieval or for further computation as required. They will be updated

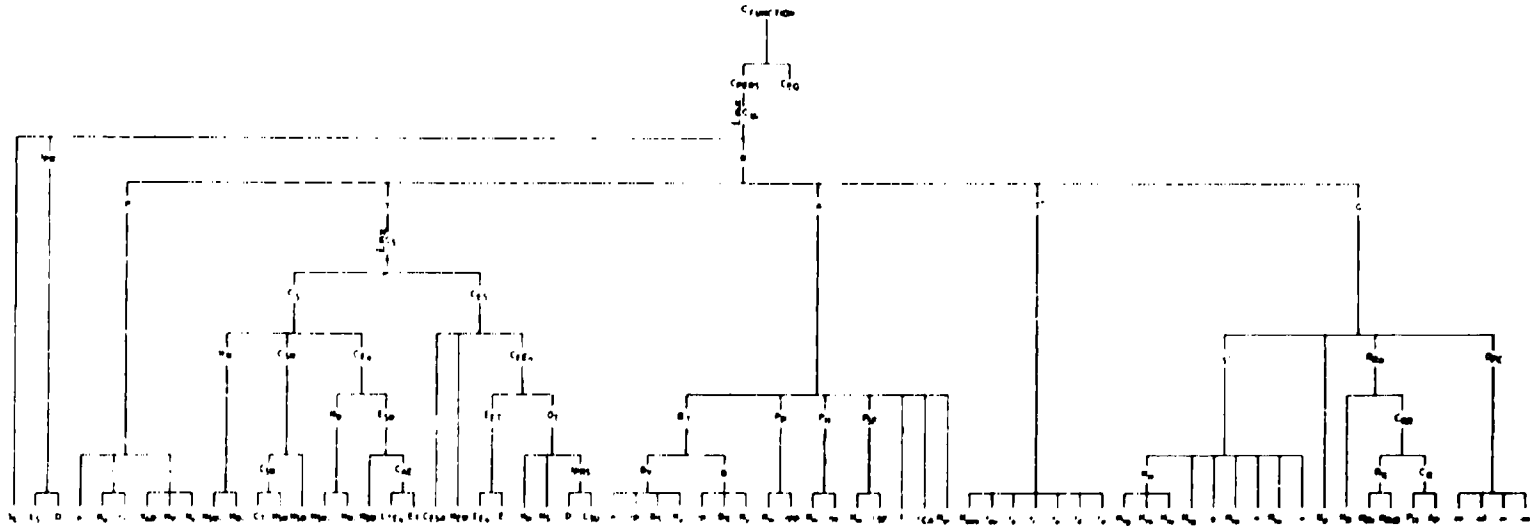

Figure 1. A Branching Model of the Cost Formula. (This Model Demonstrates How Simple Cost Elements are Combined into Complex Costs.)

TABLE 2

Inputs to be Supplied by the User

SYMBOL OR ITEM	DEFINITION		SOURCE
L_S	Lifetime of the system in years	____ yrs	Estimation by system engineers
$T_{\%}$	The percentage of the man's working time required by the function	____ %	Estimation by personnel researchers
L_{TEQ}	Estimated lifetime of training equipment	____ yrs	Estimation by training personnel and system designers
N_{EW}	Recommended number of weeks in the proposed course	____ weeks	Estimation by personnel researchers
C_{ESW}	Average cost/student week of similar schools already established, less equipment depreciation costs	$___ / student week	Estimation by personnel researchers
E	The estimated cost of a particular piece of training equipment	$____	Estimation by system engineers and cost analysts
N_{Eq}	The number of pieces of training equipment required during the time the system is in use	____	Estimation by personnel researchers and training personnel

N_S	The number of systems required by the Navy during the time the system is in use	____	Estimation by system engineers and operations analysts
N_M	The number of men per system who will take the course	____	Estimation by personnel researchers
N_y	Number of years for which a man reenlists at any particular time. Not to include any years beyond the end of duty with the function.	____ yrs	Estimation by personnel researchers
r_p	The monthly rate of pay at the time of reenlistment	$\_\_\_$/month	Estimation by personnel researchers
rate/ rating	The rate and rating of each man for each alternative	____	Estimation by personnel researchers
number of men of each rate/rating	The number of men of each rate/ rating for each alternative	____	Estimation by personnel researchers
total number of men required for this alternative	Total number of men required by this alternative. Sum of all men in all rates/ ratings	____	Estimation by personnel researchers

as often as the other elements are updated in order to keep them current. "Reported data" elements will be completely computed personnel costs. These will be stored for retrieval and will be reported to customers in addition to specific cost requests. Table 3 identifies the storage classification of some of the elements. A glossary of the elements of the personnel cost formula reported by Connelly (15) is presented in Appendix A. These formulae and elements are included as an example of the type of personnel cost formulae needed in a personnel cost data bank such as the one suggested in this report. They are not to be construed as the final formulae suggested for use in the proposed bank. The author recognizes many changes must be made in the formulae before the bank is established. These changes will be reported in future reports.

Figure 2 displays the generalized structure of the proposed system. Formulae and programs will be punched on cards and a small computer (such as the IBM 1401) will be used to record them on magnetic tape. Elements will be reported by source organizations on special forms which may be analyzed by optic scanner (such as the NCS-OMR). The data will be recorded on magnetic tape. As cost elements change in value the source organizations, using the special scanner forms, will report the new values to the data bank. These reports will be processed through the scanner as they are received. The tape will be updated and obsolete data will be discarded simultaneously. The bank may be used by individuals requesting specific costs but regular reports of costs requested most frequently may also be issued.

Automating personnel cost acquisition and computation does not eliminate the user's job. The user must define his cost needs in terms which the computer can utilize and must also supply the required input data to make the computer solve the formula for cost. Table 2 is an example of the type of information sheet a user may be asked to complete in order to provide input data to the program.

TABLE 3

Element Storage Classification

SYMBOL OF ELEMENT	INPUT BY USER	STORED ELEMENTS	COMPUTED AND STORED ELEMENTS	REPORTED ELEMENTS
A			X	X
A_P		X		
B			X	
B_T			X	
B_V			X	
$B_{\bar{x}}$		X		
C_{AE}			X	
C_{EEQ}			X	
C_{Eq}			X	
C_{ES}			X	
C_{ESW}	X			
C_{PERS}			X	X

NOTE: These symbols are defined in Appendix A.

TABLE 3
(continued)
Element Storage Classification

SYMBOL OF ELEMENT	INPUT BY USER	STORED ELEMENTS	COMPUTED AND STORED ELEMENTS	REPORTED ELEMENTS
C_R			X	
C_{RR}			X	
C_S			X	
C_{SW}			X	
C_T		X		
D		X		
E	X			
E_{ET}			X	
E_{SW}			X	
E_T		X		
G			X	X
ϵ		X		

TABLE 3
(continued)
Element Storage Classification

SYMBOL OF ELEMENT	INPUT BY USER	STORED ELEMENTS	COMPUTED AND STORED ELEMENTS	REPORTED ELEMENTS
I		X		
I_{PR}			X	X
I_{PRS}			X	
L_S	X			
L_{SU}	X			
L_{TEq}	X			
M			X	X
M_d		X		
m		X		
N_{aes}		X		
N_{Eq}	X			
N_{EW}	X			

TABLE 3
(continued)

Element Storage Classification

SYMBOL OF ELEMENT	INPUT BY USER	STORED ELEMENTS	COMPUTED AND STORED ELEMENTS	REPORTED ELEMENTS
N_e		X		
N_M	X			
N_m			X	
N_f		X		
N_{Rt}		X		
N_{RtR}		X		
N_S	X			
N_{SW}		X		
N_{tg}		X		
N_{ts}		X		
N_{tu}		X		
N_V		X		

TABLE 3
(continued)
Element Storage Classification

SYMBOL OF ELEMENT	INPUT BY USER	STORED ELEMENTS	COMPUTED AND STORED ELEMENTS	REPORTED ELEMENTS
N_w		X		
N_y	X			
N_{yr}		X		
O_{PC}			X	
O_c			X	
o_a		X		
o_d		X		
o_i		X		
o_l		X		
P			X	X
P_H			X	
P_N		X		

TABLE 3
(continued)
Element Storage Classification

SYMBOL OF ELEMENT	INPUT BY USER	STORED ELEMENTS	COMPUTED AND STORED ELEMENTS	REPORTED ELEMENTS
P_P			X	
P_{SF}			X	
p		X		
R			X	X
R_{RA}			X	
$R_{\%}$			X	
r			X	
r_C		X		
r_{CA}		X		
r_H		X		
r_P	X			
r_{PP}		X		

TABLE 3
(continued)

Element Storage Classification

SYMBOL OF ELEMENT	INPUT BY USER	STORED ELEMENTS	COMPUTED AND STORED ELEMENTS	REPORTED ELEMENTS
r_{SF}		X		
r_t		X		
rate/ rating	X			
number of men of each rate/ rating	X			
total number of men in this alterna- tive	X			
S'			X	
s		X		
T'			X	X
T"			X	X
$T_{\%}$	X			X

TABLE 3
(continued)

Element Storage Classification

SYMBOL OF ELEMENT	INPUT BY USER	STORED ELEMENTS	COMPUTED AND STORED ELEMENTS	REPORTED ELEMENTS
t_a		X		
t_d		X		
t_o		X		
t_{ou}		X		
t_r		X		
t_s		X		
u		X		
V_{AR}		X		
v			X	

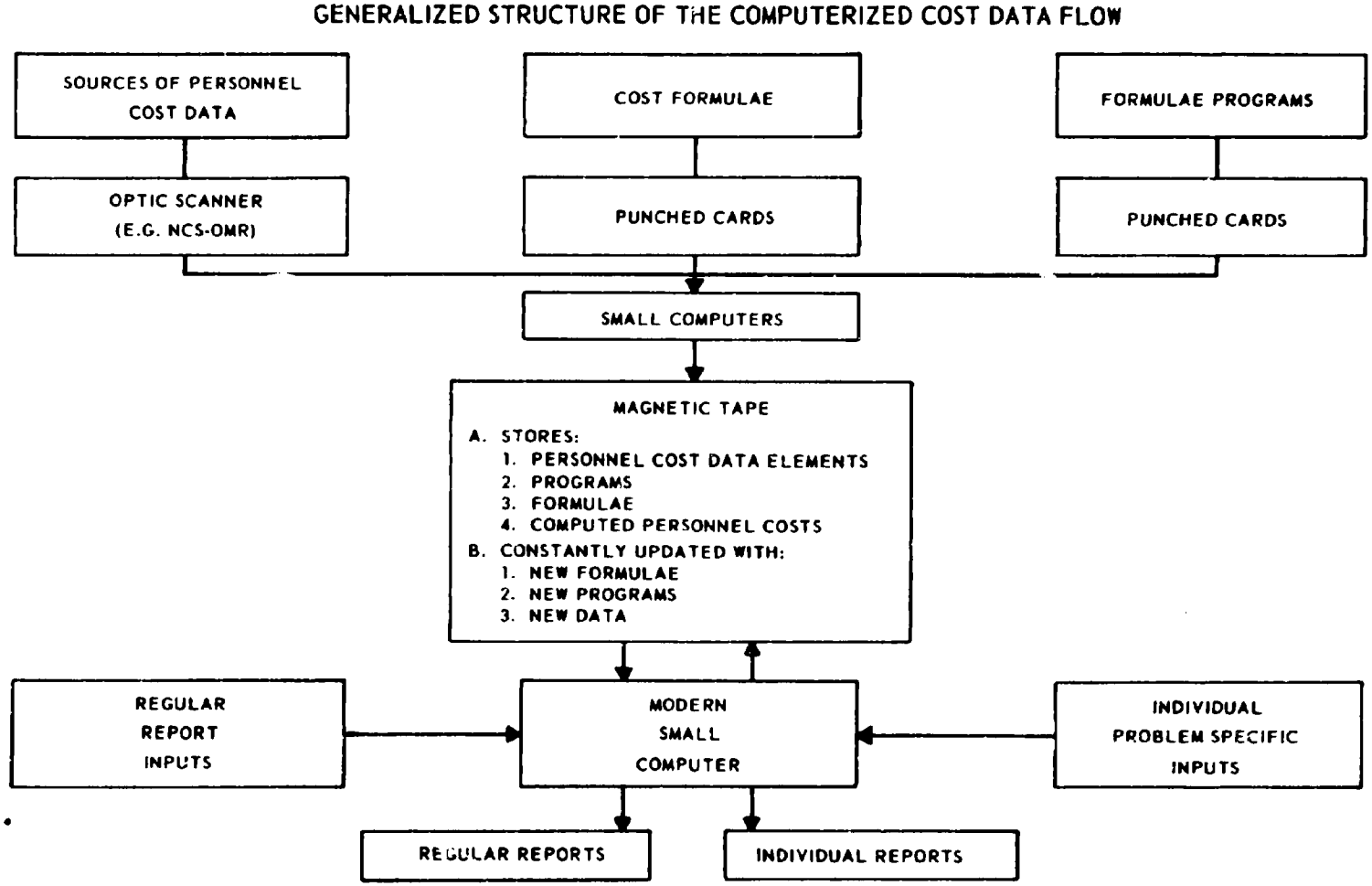

Figure 2. Generalized Structure of the Computerized Personnel Cost Data Bank

IV. IMPLICATIONS

A. Relationships With Two Other Data Banks

The proposed personnel cost data bank will be an independently operating system. However, it will exchange information with other systems and supplement information in the solution of problems. One of its major associations in this respect will be with PRISM (Personnel Requirements Information System Methodology), a proposed data bank and storage and retrieval system, which is now being developed at the U. S. Naval Personnel Research Activity at San Diego (43). Another data bank with which information will be exchanged will be a personnel performance effectiveness data bank which will eventually be developed at the Personnel Research Activity, San Diego, as part of the Cost/System Effectiveness effort. Figure 3 depicts these data banks, their interactions, and the types of information they will store and exchange. Data exchanges with other computerized systems are possible and probable. These systems are not listed here however, since they have not been committed to the information exchange at this time.

B. Effects on the Organizations Which Supply Elements to the Bank

Some of the cost source organizations' problems will be eased by the implementation of the proposed data bank. Requests for data by personnel cost researchers, now answered repeatedly throughout the year will be answered by the new system. The organization will periodically complete a simple form supplying certain requested elements. This will allow the organization's managers to budget and schedule time for this particular activity.

C. Effects on Research and Development

The major effect of the proposed system will be to facilitate predictive personnel costing conducted during the research and development of new systems and thus decrease the total effort spent in cost/effectiveness studies during system development. It is anticipated that within the Bureau of Naval Personnel it will be employed frequently in costing various manning and training options. Since the bank will provide a source of accurate predictive personnel costs, the system should have frequent use by equipment designers for cost/effectiveness and man-machine function allocation studies of alternate system designs.

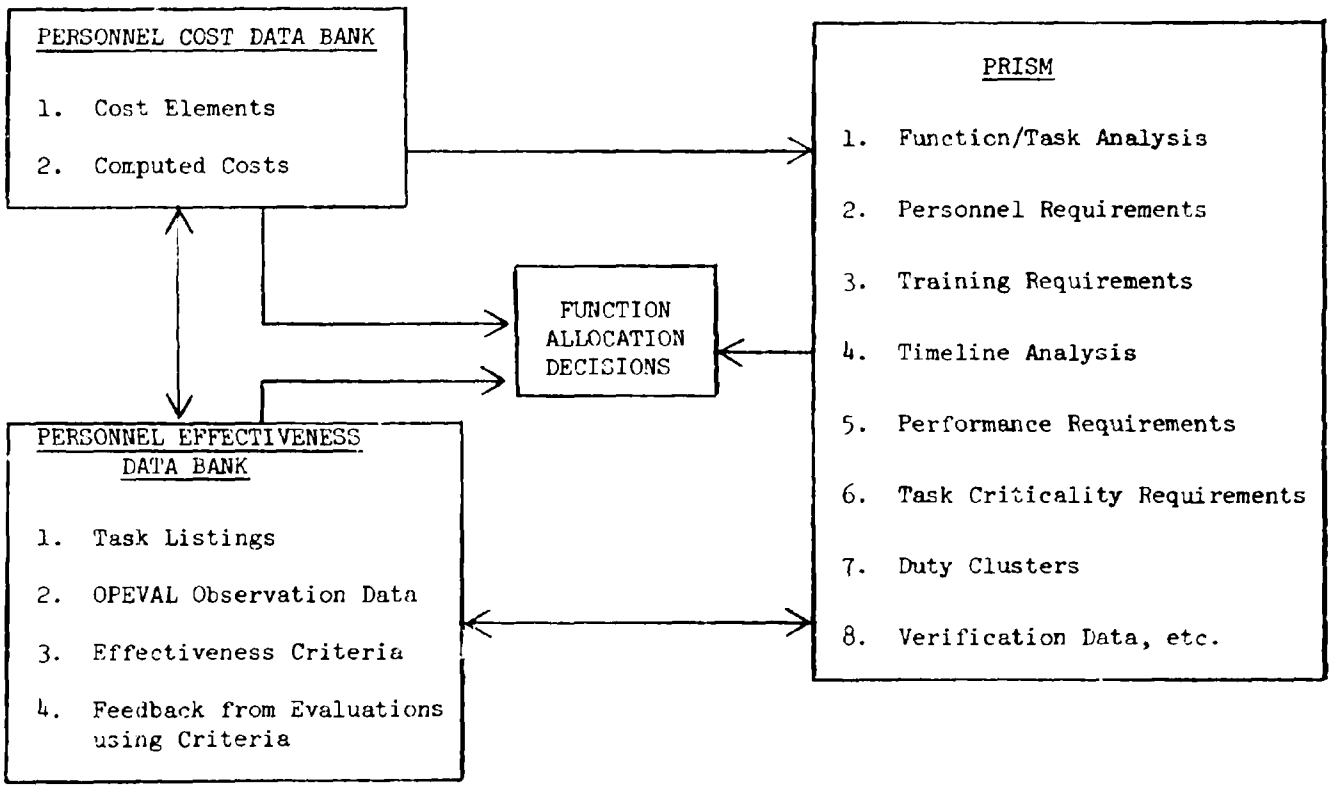

Figure 3. How the Personnel Cost Data Bank, Personnel Effectiveness Data Bank and PRISM will be Related.

V. DATA BANK PLANS, SCHEDULE, AND BUDGET

Milestones in the development and implementation of the personnel cost data bank suggested in this report are reflected in Table 4.

This schedule is based on the estimated time to accomplish the required research, development and evaluation of the proposed system. Table 5 lists budget and time estimates for these phases.

Tasks associated with the implementation, maintenance, and use of the proposed bank are listed in Table 6. Information upon which to base time and budgetary estimates is not yet available.

TABLE 1

Data Bank Developmental Milestones and End Products

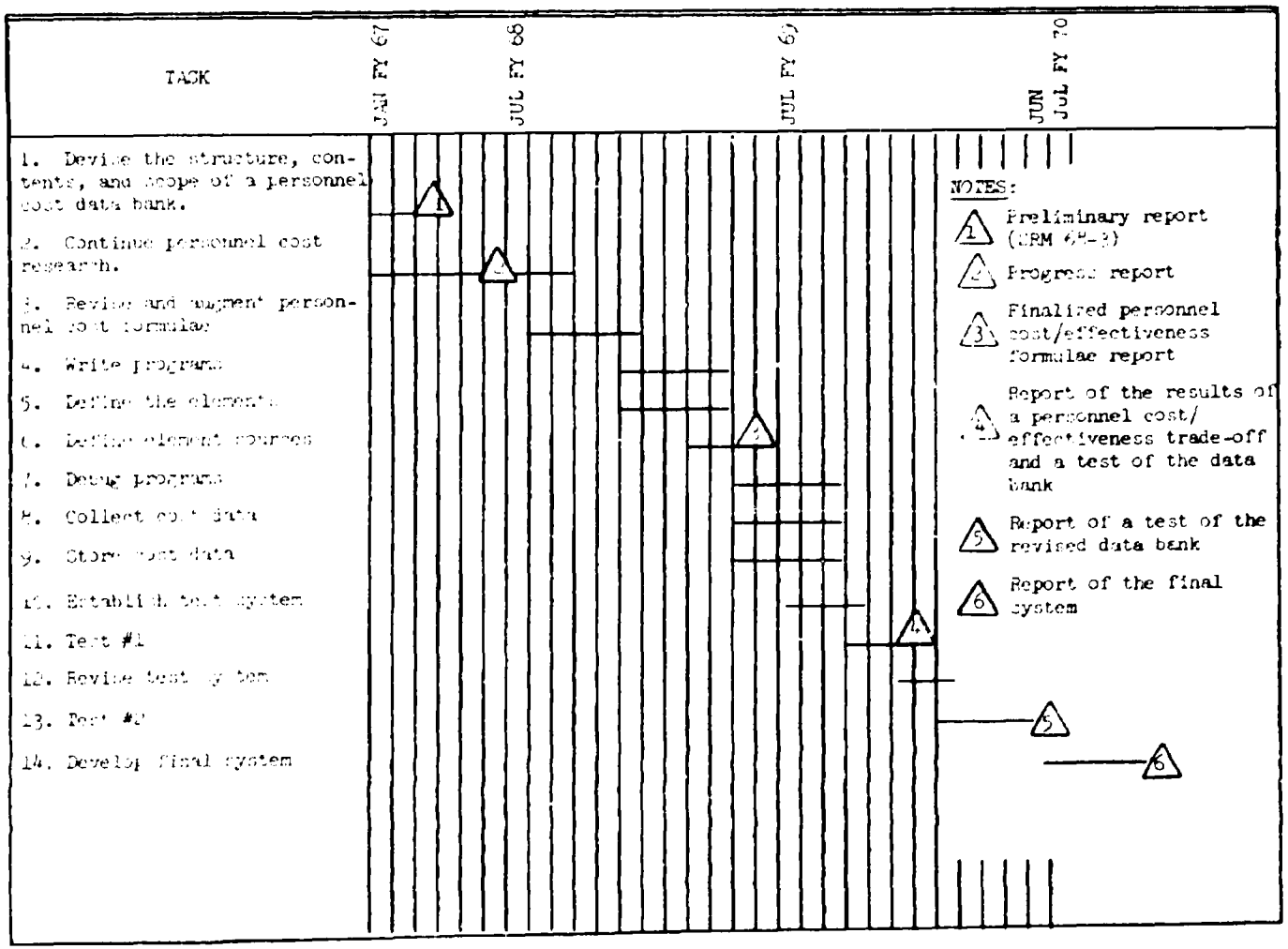

TABLE 5

Personnel Cost Data Bank Development Budget

Fiscal Year	1968	1969
Estimated Effort	1 Man/Year	1 Man/Year

TABLE 6

List of Tasks Required

(if the data bank is established, maintained, and used by the Bureau of Naval Personnel)

ESTABLISHING THE BANK
Arrange for available computers and space
Directives to source organizations
Receive data
Store data
MAINTAINING THE BANK
Receive revised data
Store revised data
Revise programs as necessary
Issue new directives as necessary
USING THE BANK
Receiving requests for data
Processing requests
Replying to requests
Individual special cost reports
Routine cost documents published

VI. CONCLUSIONS AND RECOMMENDATIONS

It is concluded that:

1. Needs for Navy personnel costs are not being adequately met at this time.

2. Solutions previously proposed do not provide adequate costs for use in early stages of equipment system development.

3. It is feasible to develop, implement, maintain, and use a computerized system for personnel cost acquisition and computation.

On the basis of this research, the following recommendations are made:

1. The data bank system proposed in this report should be developed, implemented, maintained and used as soon as possible.

2. The development plan outlined in Section V should be implemented as soon as possible.

3. During the time the data bank is being developed, procedures for establishing, maintaining, and using the system within the Bureau of Naval Personnel should be developed.

BIBLIOGRAPHY

1. Allen, Jodie, T. An Individual System/Organization Cost Model, Volume I: Concept and Application. Department of the Army (Technical Paper RAC-TP-183). (Research Analysis Corporation, McLean, Virginia, Contract No.: DA 44-188-ARO-1). January 1966.

2. Arzigian, Simon. Methods and Problems of Computation of Enlisted Personnel Costs. U. S. Naval Personnel Research Activity, Task Assignment 301.01-01W, PRAW Report No. 64-16. February 1964. pp. 59.

3. Arzigian, S, & Clary, J. Report on Enlisted Personnel Replacement Costs (BM, FT, MT, RM). PRAW Report (64-4). February 1964.

4. Arzigian, S, & Couloumbis, T. Report on Enlisted Personnel Replacement Costs. PRAW Report (63-8). May 1963.

5. Arzigian, S, & Couloumbis, T. Report on Enlisted Personnel Replacement Costs. PRAW Report (63-22). August 1963.

6. Automatic Data Processing Glossary. Executive Office of the President, Bureau of the Budget. December 1962.

7. Boren, H. E., Jr. Individual Weapon System Computer Cost Model. The RAND Corporation, Santa Monica, California. RM 4165PR, AF49 638 700. July 1964.

8. Bradley, B. D. Building a New Force Structure Cost Analysis Model. The RAND Corporation, Santa Monica, California, Memorandum RM 4765-PR. October 1965

9. Byer, Robert J., Hard, Ronald W., Lynch, Edward J., Jr., Morse, Russell A., Jr., Pulscak, Michael W., Spitzer, Murray. The CAPRI System for Naval Manpower Planning and Control. New Developments Research Branch, Personnel Research Division, Bureau of Naval Personnel (Report No. ND 64-30). (Operations Research, Incorporated, Silver Spring, Maryland, Contract No. Nonr 3949(00)) (Technical Report 235), Volume I: Design and Operation). November 1963.

10. Clary, James N. Officer Personnel Costs: Naval Academy Graduate. Naval Personnel Program Support Activity, Naval Personnel Research Laboratory, Washington, D. C., WRM 65-3. April 1965.

11. Clary, James N. Officer Personnel Costs: NROTC - Regular - NROTC - Contract. Naval Personnel Program Support Activity, Personnel Research Laboratory, Washington, D. C., WRM 65-6. May 1965.

12. Clary, James N. Officer Personnel Costs: Aviation Officer Candidate (AOC). Naval Personnel Program Support Activity, Personnel Research Laboratory, Washington, D. C., WRM 66-1. July 1965.

13. Clary, James N. Officer Personnel Costs: Naval Aviation Cadet (NAVCAD). Naval Personnel Program Support Activity, Personnel Research Laboratory, Washington, D. C., WRM 66-14. November 1965.

14. Clary, James N., & Arzigian, Simon. Personnel Costs for Ten Selected Ratings (AC, AE, AQ, AT, AX, ET, FT MM, RD, ST). Naval Personnel Research Laboratory, Washington, D. C., WRM 65-2. April 1965.

15. Connelly, Marilee M. The Feasibility of Deriving a Cost/Effectiveness Formula for Man/Machine Function Allocation. U. S. Naval Personnel Research Activity, San Diego, California, SRM 67-4. September 1966.

16. Conner, Richard D., & May, R. V., Jr. Applications of a Computerized Model in Enlisted Personnel Planning. U. S. Naval Personnel Research Activity, San Diego, California, SRR 66-3. September 1965.

17. Cost-Effectiveness Optimization (Summary, Conclusions and Recommendations). WSEIAC, Final Report of Task Group IV, Headquarters, Air Force Systems Command, Andrews Air Force Base, Maryland. AFSC-TR-65-4, Volume 1. January 1965.

18. Cost-Effectiveness Optimization (Technical Supplement). WSEIAC, Final Report of Task Group IV, Headquarters, Air Force Systems Command, Andrews Air Force Base, Maryland. AFSC-TR-65-4, Volume III. January 1965.

19. Davis, Gordon B. An Introduction to Electronic Computers. Associate Professor and Director, The School of Business Administration Computer Center, University of Minnesota. San Francisco, California: McGraw-Hill Company. Undated.

20. Fisher, G. H. Weapon System Cost Analysis. The RAND Corporation, 1700-Main Street, Santa Monica, California (P-823). (Office of Technical Services, U. S. Department of Commerce, Washington, D. C. (AD422839)). 30 July 1956.

21. Freiberger, Walter F. & Prager, William. Applications of Digital Computers. Palo Alto, California. Ginn and Company, 1963.

22. Gagliardi, Ugo O. Data File Size and Its Relation to the Bayesian Effectiveness of an Information Retrieval System. Decision Sciences Laboratory, Electronic Systems Division, Air Force Systems Command, United States Air Force, L. G. Hanscom Field, Bedford, Massachusetts, (Interim Report ESD-TR-65-275). (Dunlap and Associates, Inc., Darien, Connecticut, Contract No.: AF 19 (628)-5057)). Project 2806. Task 280609. April 1965.

23. Gettings, R. W. Proposed Outline of an Enlisted Personnel Cost Model. U. S. Naval Personnel Research Laboratory, Washington, D. C., WRM 66-66. October 1966.

24. Gettings, Roy W. Proposed Content of an Enlisted Personnel Cost Model. U. S. Naval Personnel Research Laboratory, Washington, D. C., WRM 67-18. December 1966.

25. Ginberg, Paul & Young, John D. Cost-Resource Models for Program Planning. TEMPO General Electric Company, Santa Barbara, California, 65TMP-73. October 1965.

26. Goodyear, Burton J. Training Equipment and Building Amortization Study. Naval Personnel Program Support Activity, Personnel Research Laboratory, Washington, D. C., WRM 66-29. January 1966.

27. Inman, Kenneth L. Fundamentals of Electronic Data Processing, A Programmed Text. Education Research Department, Honeywell Electronic Processing Division, Wellesly Hills, Massachusetts. Englewood Cliffs, New Jersey: Prentice-Hall, Inc. 1964.

28. Jackson, B, Mann, L, & Primas, W. Officer Personnel Costs for Use in ASW Surface Ship Systems Cost Effectiveness Comparisons. Naval Personnel Research Laboratory, Washington, D. C., Report 65-63. June 1965.

29. Jannsen, T. J., Glazer, H., & Des Roches, J. C. User's Manual for the Computerized Electronic System Cost Model. MITRE Corporation, Bedford, Massachusetts. October 1964.

30. Johanningsmeier, Walter F., & Lancaster, F. Wilfrid. Project SHARP (Ships Analysis and Retrieval Project) Information Storage and Retrieval System: Evaluation of Indexing Procedures and Retrieval Effectiveness. Bureau of Ships, Department of the Navy, Washington, D. C.,(NAVSHIPS 250-210-3). (Herner and Company, Washington, D. C., Contract: NObs 88417). March 1963 - June 1964.

31. Johnson, L. B. Memorandum for Deputy Chief of Naval Personnel. Department of the Navy, Office of the Chief of Naval Operations, Washington, D. C. 28 June 1966.

32. Knorr, K. On the Cost-Effectiveness Approach to Military R&D: Critique. RAND Corporation. June 1966.

33. Mann, L. O., Primas, W. H., & Jackson, R. J. Enlisted Personnel Costs for Use in ASW Surface Ship Systems Cost-Effectiveness Comparisons. Personnel Research Division, Bureau of Naval Personnel, Washington, D. C., Report No. ND 65-40. December 1964.

34. Moores, B. L. User's Manual for the Computerized Electronic System Cost Model: 7030 Modifications. MITRE Corporation, Bedford, Massachusetts. October 1964.

35. Newell, Allen, Tonge, Fred M., Feigenbaum, Edward A., Green, Bert F., Jr., Mealy, George H. & Kelly, Hugh S. Information Processing Language-V Manual. The Rand Corporation. Englewood Cliffs, New Jersey: Prentice-Hall, Inc. 1961.

36. Nonconventional Technical Information Systems in Current Use. Office of Science Information Service, National Science Foundation, NSF-59-49, No. 2. September 1959.

37. Novick, David. System and Total Force Cost Analysis. The RAND Corporation, Memorandum RM-2695-PR. April 1961.

38. Proceedings of Department of Defense Cost Research Symposium. Office of Assistant Secretary of Defense (Systems Analysis), 400 Army-Navy Drive, Arlington, Virginia. 2-3 March 1966.

39. Pulsak, Michael W., Cleveland, Robert H., Hard, Ronald W., Raphaelson, Elliot, Beeker, George & Morse, A. Russell, Jr. The CAPRI System for Naval Personnel Program Management, Volume I: Description and Operation. New Developments Research Branch, Personnel Research Division, Bureau of Naval Personnel , ND 65-28. (Operations Research Incorporated, 1400 Spring Street, Silver Spring, Maryland, Contract No.: Nonr 3949(00)). Technical Report 322. May 1965.

40. Results of Department of Defense Cost Research Survey. Office of Assistant Secretary of Defense (Systems Analysis). Fall 1965.

41. Safeer, Harvey, Bernstein, Gilbert, & Wax, Stephen R. A Computer Model for Projecting Civilian and Military Manpower. Research Analysis Corporation, McLean, Virginia, RAC Paper RAC-P-13. November 1965.

42. Schmidt, Richard N. & Meyers, William E. Introduction to Computer Science and Data Processing. Holt, Rinehart & Winston, Inc., 383 Madison Ave., New York. 1965.

43. Smith, H. G. Feasibility of a Personnel Requirements Information System Methodology (PRISM); Preliminary Phase I Report. U. S. Naval Personnel Research Activity, San Diego, California, SRM 67-14. January 1967

44. Utilization Study of the TITAN II Basic Data Pool. (Final Report). United States Air Force, Air Force Systems Command, Ballistic Systems Division, BSD-TR-65-194. 30 July 1965.

45. Waks, N. Future Trends in Military Information Systems Concepts. Directorate of Computers, Air Force Systems Command, United States Air Force, L. G. Hanscom Field, Bedford, Massachusetts, (Technical Report No. ESD-TR-65-141, TM-04170/0000/01/0/00, Project 505.0). (The MITRE Corporation, Bedford, Massachusetts, Contract: AF19(628)-5165). October 1965.

46. Weapon System Master Index, Basic Data Monograph, WS 107C, Part I: Description of Basic Data Pool. Headquarters, Ballistic Systems Command, United States Air Force, Norton Air Force Base, California, (Weapon System 107C TITAN II). (Martin Company, Denver, Colorado, Contract: AF04(694)-472). February 1965.

47. Weapon System Master Index, Basic Data Monograph, Part II: Use and Maintenance of Basic Data Pool. Headquarters, Ballistic Systems Division, Norton Air Force Base, California, (CR-62-162 (Vol. IV) (Part II) (Approval No. 21-R138.1)). (Martin Company, Denver, Colorado, Contract AF04(694)-472). February 1965.

48. Webb, J. Scott, Willis, & Anderson, Ronald D. A Selected Bibliography on Cost Effectiveness and Man/Machine Function Allocation. U. S. Naval Personnel Research Activity, San Diego, California, SRM 66-4. August 1965.

49. Westerman, Dean P., & Mathias, Ronald F. A Cost Model for Use in Cost-Effectiveness Analyses of Dissimilar Weapon Systems. Ballistic Research Laboratories, Aberdeen Proving Ground, Maryland, MR 1602, IM023201A098. September 1964.

50. Willis, Joe E. Measuring Personnel Effectiveness: Special Progress Report. U. S. Naval Personnel Research Activity, San Diego, California. (A special working document, not for general distribution). December 1966.

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APPENDIX A

INDEX OF SYMBOLS
(ALPHABETICAL ORDER)

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APPENDIX A

INDEX OF SYMBOLS
(ALPHABETICAL ORDER)

A	Pay and allowances through the end of duty time with the function
A_P	Actuarial percentage for retirement system cost
B	Sum of regular reenlistment bonus (this amount may not exceed $2,000)
B_T	The total amount of reenlistment bonus paid to any single man
B_V	The Variable Reenlistment Bonus (applies to certain ratings only and may be applied only to the first reenlistment)
$B_{\%}$	The percentage of pay given as a bonus for the specific reenlistment
C_{AE}	Annual equipment cost
C_{EEq}	The estimated per capita cost of training equipment
C_{EQ}	Total equipment cost
C_{Eq}	The per capita cost of equipment for a specific school
C_{ES}	Estimated per capita cost of recommended course
C_{ESW}	Average cost/student week of similar schools already established, less equipment depreciation costs
$C_{FUNCTION}$	Total function cost
C_{PERS}	Total personnel cost
C_R	The cost of the Navy's retirement system

C_{RR}	Cost of retirement for a given rating
C_S	The cost/student of a specific school attended
C_{SW}	The cost/student week, or the weighted average cost/student week
C_T	The total annual cost of a specific school, less student pay and allowances
D	Duty time with the function or system in years
E	The estimated cost of one (1) piece of training equipment
E_{ET}	The estimated total cost of training equipment
E_{SW}	Equipment cost/student week
E_T	Total school equipment cost
G	General support cost
g	Rate of authorized donations discharge gratuities
I	Initial clothing allowance
i	Each individual case
I_{PR}	Index of personnel replacement
I_{PRS}	Index of personnel replacement for schools
L_S	Lifetime of the system in years
L_{SU}	Estimated time the system will be in use
L_{TEq}	Estimated lifetime of training equipment
M	The cost of one man in the function by his rate/rating

M_d	Total medical cost
m	The Variable Reenlistment Bonus multiple which applies to a given rating
N	The Nth case
N_{aes}	Average enlisted strength as estimated by Pers-H111
N_{Eq}	The number of pieces of training equipment required during the time the system is in use
N_{EW}	Recommended number of weeks in the proposed course
N_e	Number of enlistments
N_M	The number of men per system who will take the course
N_m	The average number of months in the pay grade for the rating being costed, or the number of months a man qualifies for a type of pay
N_R	Number in the rating
N_{Rt}	Total number retiring from the Navy
N_{RtR}	Number retiring from the rating (annually)
N_S	The number of systems required by the Navy during the time the system is in use
N_{SW}	Number of student weeks per year reported for the specific school
N_{tg}	Number terminating with discharge gratuities
N_{ts}	Number terminating with severance pay
N_{tt}	Total number terminating

N_{tu}	Number terminating with lump sum terminal leave
N_V	Number of vehicles used in recruiting
N_W	The catalogue length of course in weeks, or the weighted average length of course in weeks
N_y	Number of years of reenlistment e. this particular time
N_{yr}	The average number of years in a pay grade for the rating being costed
O_{PC}	Other military personnel costs
O_T	Total student output of a course during the time the system is in use
o_a	Cost of apprehension of military deserters, absentees, and escaped military prisoners
o_d	Cost of death gratuities
o_i	Cost of interest on enlisted personnel deposits
o_l	Cost of servicemen's group life insurance
P	Total procurement cost
P_H	Total hazardous duty pay
P_N	Total Navy pay
P_P	Total proficiency pay
P_{SF}	Total sea and foreign duty pay
p	Basic per capita procurement cost

R	The cost of a particular rate/rating
R_{RA}	Per capita rating retirement allocation
$R_{\%}$	The percentage of those retiring who are from a given rating
r	Per capita rental cost of buildings used in procurement
r_C	The monthly military compensation rate
r_{CA}	The annual military compensation including basic pay, quarters, subsistence, maintenance clothing allowance, and Federal Insurance Contributions Act (FICA)
r_H	The rate of hazardous duty pay for the individual pay grade
r_P	The monthly rate of pay at the time of reenlistment
r_{PP}	The rate of proficiency pay for the individual pay grade
r_{SF}	The rate of sea or foreign duty pay for a particular pay grade
r_t	Total cost of rentals used in procurement
S'	Estimated separation cost per man
s	Rate of severance pay - disability
T'	Training cost through the end of duty time with the function
T''	Transportation cost through the end of duty time with the function
$T_{\%}$	The percentage of the man's working time required by the function

t_a	Accession travel (Recruiting station to Recruit training center)
t_d	Travel from training center to first duty station
t_o	Operational move, within the United States
t_{ou}	Travel of organized units
t_r	Rotational move, outside the United States
t_s	Separation travel
u	Rate of lump sum terminal leave ---- unused leave
V_{AR}	Vehicle amortization rate in dollars per vehicle
v	Per capita vehicle amortization cost due to procurement

APPENDIX B

DERIVATION OF A PERSONNEL COST FORMULA FOR COST/EFFECTIVENESS FUNCTION ALLOCATION DECISIONS

APPENDIX B

DERIVATION OF A PERSONNEL COST FORMULA FOR COST/EFFECTIVENESS FUNCTION ALLOCATION DECISIONS

$$C_{FUNCTION} = C_{EQ} + C_{PERS}$$

$$C_{PERS} = \sum_{i=1}^{N} M_i$$

NOTE: Symbols are defined in Appendix A.

$$M = (I_{PR})(T_{\%})(R)$$

$$I_{PR} = \frac{L_S}{D}$$

$$R = P + T' + A + T'' + G$$

$$P = p + r + v$$

$$r = \frac{r_t}{N_e}$$

$$v = \frac{(N_V)(V_{AR})}{N_e}$$

$$T' = \sum_{i=1}^{N} C_{Si}$$

$$C_S = N_W C_{SW} + C_{Eq}$$

$$C_{SW} = \frac{C_T}{N_{SW}}$$

$$C_{Eq} = (E_{SW})(N_W)$$

$$E_{SW} = \frac{C_{AE}}{N_{SW}}$$

$$C_{AE} = \frac{E_T}{L_{TEq}}$$

$$N_W = \frac{N_{W_1} N_{SW_1} + N_{W_2} N_{SW_2}}{N_{SW_1} + N_{SW_2}}$$

$$C_{SW} = \frac{C_{SW_1} N_{SW_1} + C_{SW_2} N_{SW_2}}{N_{SW_1} + N_{SW_2}}$$

$$C_{ES} = N_{EW} C_{ESW} + C_{EEq}$$

$$C_{EEq} = \frac{E_{ET}}{O_T}$$

$$E_{ET} = (E)(N_{Eq})$$

$$O_T = (N_S)(N_M)(I_{PRS})$$

$$I_{PRS} = \frac{L_{SU}}{D}$$

$$A = \sum_{i=1}^{N} (N_{yr} r_{CA})_i + I + P_{SF} + P_H + P_P + B_T$$

$$P_{SF} = \sum_{i=1}^{N} (r_{SF} N_m)i$$

$$P_H = \sum_{i=1}^{N} (r_H N_m)i$$

$$P_P = \sum_{i=1}^{N} (r_{PP} N_m)i$$

$$B = \sum_{i=1}^{N} (N_y B_{\%} r_p)i$$

$$B_V = (N_y B_{\%} r_p)(m)$$

$$B_T = B + B_V$$

$$T'' = \frac{t_a + t_d + t_o + t_r + t_s + t_{cu}}{N_{aes}}$$

$$G = S' + M_d + R_{RA} + O_{PC}$$

$$N_{tt} = N_{tu} + N_{ts} + N_{tg}$$

$$S' = \frac{(u)(N_{tu}) + (s)(N_{ts}) +)g)(N_{tg})}{N_{tt}}$$

$$C_R = (A_P)(P_N)$$

$$R_{\%} = \frac{N_{RtR}}{N_{Rt}}$$

$$C_{RR} = (C_R)(R_{\%})$$

$$R_{RA} = \frac{C_{RR}}{N_R}$$

$$O_{PC} = o_a + o_i + o_d + o_l$$

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13. ABSTRACT

The purpose of this study is to develop the structure of a data bank system which will facilitate the acquisition and computation of personnel costs needed for cost/effectiveness predictions. The Navy's need for adequate personnel cost information, especially during the development of new systems, was investigated. Data bank systems and cost models were examined. None, however, could provide predictive, system oriented personnel costs upon which to base function allocation decisions. The concept of using a computerized system for cost acquisition and computation was evaluated and found feasible. Consequently, the structure, contents, and formulae to be used in such a data bank system were derived and are formally proposed within this report. The tasks required to develop the system are delineated.

On the basis of this research, it is recommended that the personnel cost data bank system proposed herein be fully developed as soon as possible. Solutions to the problems of establishing, maintaining, and using the system for system development cycle support should be sought during the time the cost data system is being developed. The system should be implemented, maintained, and used as soon as possible.

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